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The impact of electronic data interchange on reducing bullwhip effect and supply chain inventory costs

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Abstract

This paper uses a web-based supply chain simulator to demonstrate the potential benefits of using Electronic Data Interchange (EDI) in supply chain management. The simulation experiment measures the impact of EDI on mean inventory costs, orders placed, cumulative cost, amplification and net excess stock in the supply chain. In all cases, there are statistically significant reductions in the values of the variables studied for the simulations with EDI. The comprehensive use of EDI provides substantial savings in costs as well as notable improvements in supply chain management.

Keywords: Supply chain; Bullwhip effect, EDI; Business simulators; Supply chain simulators; Beer Game

1. Introduction

The aggregated behavior of supply chains has been investigated by many authors (e.g., Mitchell, 1923; Hansen, 1951; Forrester, 1958, 1961; Mitchell, 1971; Zarnowitz, 1973; Blanchard, 1983; Sterman, 1989; Krane and Brawn, 1991). Their research shows three typical behavioral patterns which characterize the distortion of demand moving upstream in the chain (retailers/wholesalers/distributors/factory): oscillation, amplification and phase lag. This distortion in demand is known as the *bullwhip effect* (see Senge, 1990; Blackburn, 1991; Hammond, 1994; Lee et al., 1997a; Holmström, 1997; Frangoo and Wooters, 2000). This distortion produces the same patterns on the inventories throughout all the elements of the supply chain, as illustrated in Figs. 1

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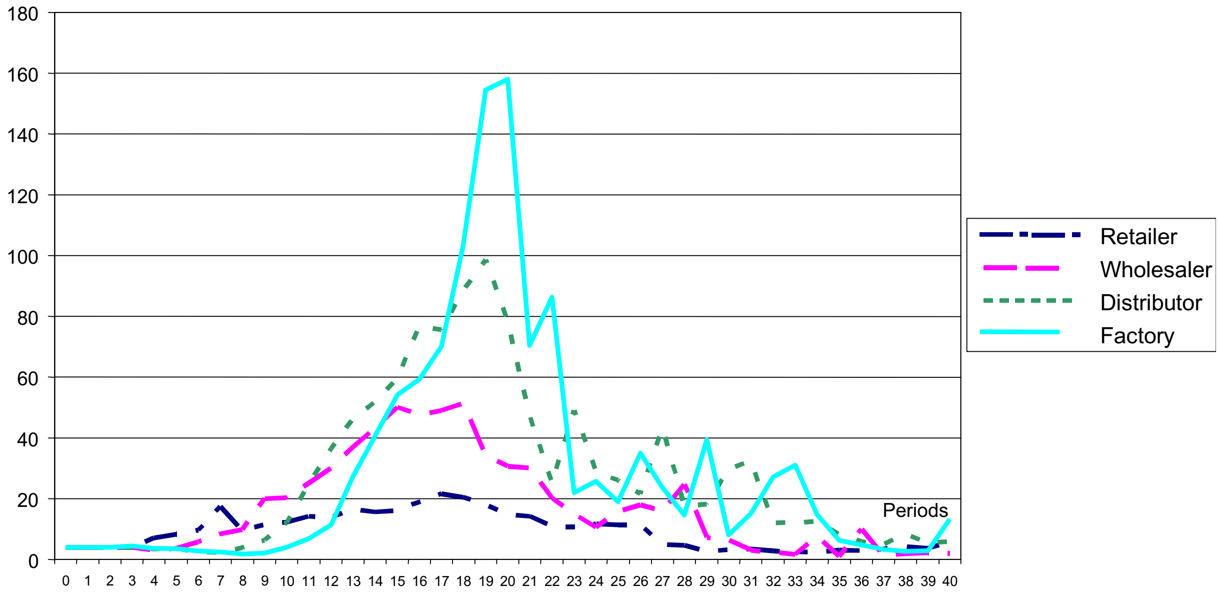

Fig. 1. Orders placed in a supply chain.

and 2: (a) the orders and inventory demonstrate large amplitude-fluctuations at the different nodes in the supply chain (*oscillation*); (b) a gradual increase in variance across all the elements in the chain (*amplification* [1]); and (c) after a certain delay, the peak of orders placed, which commences at the retailer, extends to the rest of the components further upstream (*phase lag*). The same occurs with the appearance and later disappearance of inventory shortage (Fig. 2).

A small variance in actual consumer demand can result in the various companies operating at different stages of a supply chain being subject to the bullwhip effect, which gives rise to a number of well-known problems: the accumulation of excess inventories at certain times, followed by serious inventory shortages; poor customer service at other times; excess or insufficient capacity, depending on the case; and unstable production and inefficient production planning and scheduling, leading to higher costs resulting from the corrective actions that have to be taken (investments in new capacity, overtime working, deliveries by urgent transport, etc.). [2]

A number of studies have investigated the various causes of the bullwhip effect (see Forrester (1961); Kahn, 1987; Sterman, 1989; Eichenbaum, 1989; Blackburn, 1991; Naish, 1994; Diehl and Sterman, 1995; Towill, 1996; Lee et al., 1997b). A number of these authors highlight time delays between supply chain links (Sterman, 1989; Blackburn, 1991; Diehl and Sterman, 1995; Metters, 1997; Chen, 1999). For example, Metters (1997, p. 99) stresses that "a lack of inter-company

[1] Amplification can be measured in this case by the ratio of variance of perceived demand to the manufacturer/variance of consumer demand (see Sterman, 1989).

[2] Trade estimates suggest that these problems can result in excess costs in the range of 12.5–25% (Kurt Salmon Associates, 1993 (quoted by Lee et al., 1997b)).